

## ORIGINAL ARTICLE

# Predictive value of a bleeding score for postpartum hemorrhage

Ada Gillissen MD, PhD<sup>1,2,3</sup>  | Thomas van den Akker MD, PhD<sup>3,4</sup>  |  
 Camila Caram-Deelder PhD<sup>1,2</sup>  | Dacia D. C. A. Henriquez MD, PhD<sup>1,2,3</sup>  |  
 Sebastiaan W. A. Nij Bijvank MD<sup>5</sup>  | Kitty W. M. Bloemenkamp MD<sup>6</sup>  |  
 Jeroen Eikenboom MD<sup>7</sup>  | Johanna G. van der Bom MD<sup>1,2</sup> 

<sup>1</sup>Centre for Clinical Transfusion Research, Sanquin Research, Leiden, The Netherlands

<sup>2</sup>Department of Clinical Epidemiology, Leiden University Medical Centre, Leiden, The Netherlands

<sup>3</sup>Department of Obstetrics, Leiden University Medical Centre, Leiden, The Netherlands

<sup>4</sup>National Perinatal Epidemiology Unit, University of Oxford, Oxford, United Kingdom

<sup>5</sup>Department of Obstetrics, Isala Clinics, Zwolle, The Netherlands

<sup>6</sup>Department of Obstetrics, Birth Centre Wilhelmina's Children Hospital, University Medical Centre Utrecht, Utrecht, The Netherlands

<sup>7</sup>Department of Internal Medicine, Division of Thrombosis and Hemostasis, Leiden University Medical Centre, Leiden, The Netherlands

## Correspondence

Johanna G. van der Bom, Leiden, The Netherlands. Email: j.g.vanderbom@lumc.nl

## Abstract

**Background:** A reliable screening tool that could contribute to the identification of women with an increased risk of postpartum hemorrhage would be of great clinical significance.

**Objectives:** The aim of this study was to examine the added predictive value of a bleeding assessment tool for postpartum hemorrhage exceeding 1000 mL.

**Patients/Methods:** Prospective two-center cohort study among 1147 pregnant women visiting the outpatient clinic or the maternity ward who completed a bleeding assessment tool prior to birth. The condensed MCMDM-1VWD bleeding assessment tool was adjusted to a questionnaire that could be used as a self-assessment bleeding tool. A score of  $\geq 4$  was considered to be abnormal.

**Results:** In the 1147 pregnant women in our cohort, bleeding scores ranged from  $-3$  to  $13$ , with a median of  $1$  (IQR  $-1$  to  $3$ );  $197$  (17%) women developed postpartum hemorrhage. Among women with a history of postpartum hemorrhage 29% developed postpartum hemorrhage. Among 147 women with an abnormal bleeding score ( $\geq 4$ ),  $27$  (18%) developed postpartum hemorrhage, whereas the remaining 170 cases of postpartum hemorrhage had a normal bleeding score. Despite the high incidence of postpartum hemorrhage, the ability of the bleeding score to predict postpartum hemorrhage was poor: area under receiver operating curve  $0.53$  (95% CI  $0.49$ - $0.58$ ) for postpartum hemorrhage (PPH)  $\geq 1000$  mL.

**Conclusions:** A history of significant postpartum hemorrhage was associated with an increased risk of subsequent postpartum hemorrhage. However, screening with a bleeding assessment tool did not help to discriminate women who will develop postpartum hemorrhage from women who will not.

## KEYWORDS

bleeding assessment tool, bleeding score, postpartum hemorrhage, prediction, pregnancy

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## Essentials

- The added value of bleeding scores for identifying women with a high risk of excessive blood loss at childbirth is unknown.
- Prospective two-center cohort study in pregnant women with follow-up until childbirth.
- A history of excessive blood loss at childbirth is associated with a 30% increased risk of subsequent postpartum hemorrhage.
- Bleeding scores do not add to the identification of women who will develop postpartum hemorrhage.

## 1 | INTRODUCTION

Postpartum hemorrhage continues to be a leading cause of maternal health problems worldwide.<sup>1-4</sup> Although risk factors are often known to be present during pregnancy and birth, postpartum hemorrhage frequently occurs unexpectedly.<sup>5-7</sup> Also, women with known risk factors for postpartum hemorrhage frequently do not bleed excessively following childbirth. It has therefore proven difficult to develop a reliable prediction model for postpartum hemorrhage based on clinical peripartum risk factors.<sup>5,8,9</sup>

In general clinical practice, assessment of bleeding risk is performed by assessing clinical history, performing a physical examination, and sometimes the use of screening coagulation tests.<sup>10,11</sup> However, coagulation testing to predict bleeding risk prior to invasive procedures was found to be not useful due to limited sensitivity and specificity of the tests and low prevalence of bleeding disorders.<sup>12,13</sup> The best results for prior assessment of bleeding risk come from more structured approaches to history taking by means of bleeding assessment tools (BATs), originally developed to determine the likelihood of the presence of a bleeding disorder (von Willebrand disease).<sup>14-16</sup> In adults with von Willebrand disease, bleeding assessment tools have shown to be able to predict future bleeding events.<sup>17</sup> Another very useful application of bleeding assessment tools would be the ability contribute to the identification of subjects who are more likely to bleed excessively *prior* to their exposure to invasive procedures, surgery and also childbirth.<sup>18</sup> The main causes for postpartum hemorrhage are known to be obstetrical, but undiagnosed bleeding disorders can increase the risk of postpartum hemorrhage about threefold.<sup>7,19</sup> Since postpartum hemorrhage remains an event that could have serious consequences including severe acute maternal morbidity and mortality, it would be of great significance to have a reliable screening tool that could contribute to the identification of women with an increased risk of excessive blood loss prior to childbirth.

The aim of this study was to examine the added predictive value of the TeMPOH-2 self-BAT derived from the condensed MCMDM-1VWD (Molecular and Clinical Markers for the Diagnosis and Management of Type 1 von Willebrand disease) BAT in the prediction of postpartum hemorrhage.

## 2 | MATERIALS AND METHODS

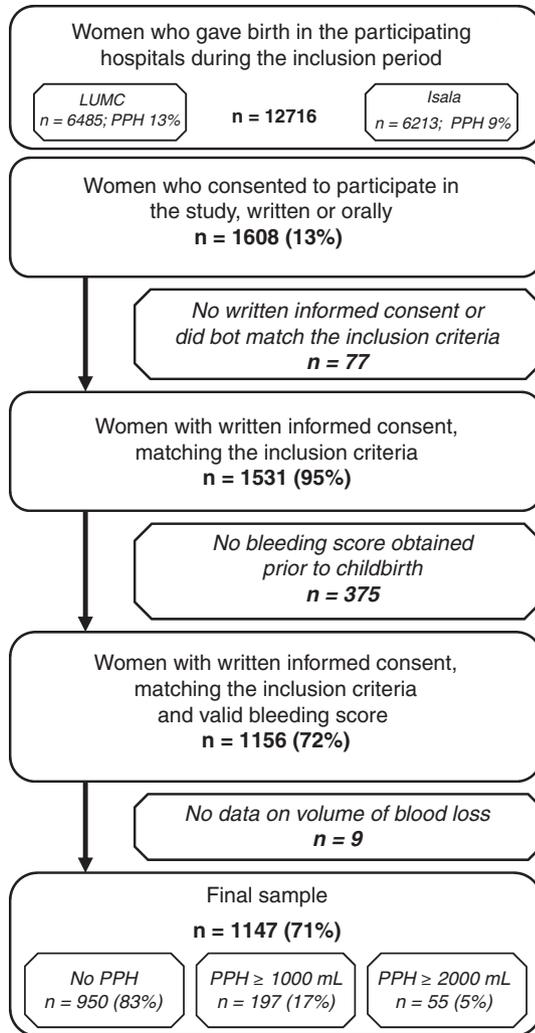
### 2.1 | Design and study population

We studied women who had been included in the TeMPOH-2 (Towards better Prognostic and Diagnostic strategies for Major

Obstetric Hemorrhage) study, a prospective cohort of pregnant women in the Netherlands between February 2015 and April 2018. The women were recruited during their pregnancy at the outpatient clinics and maternity wards from two of the three participating hospitals, the Leiden University Medical Centre in Leiden and the Isala Clinics in Zwolle. Included women were monitored for the occurrence of postpartum hemorrhage and followed until discharge from hospital after childbirth. At inclusion women were asked to complete a questionnaire containing a bleeding assessment tool. Answers to the questions of the bleeding assessment tool pertained to a woman's pre-pregnancy condition. Postpartum hemorrhage was defined as any blood loss  $\geq 1000$ -mL blood loss within 24 hours after childbirth. Blood loss  $\geq 2000$  mL was a secondary end point. To include as many women as possible, study information was provided by a trained nurse at a set third trimester consultation that was scheduled for all pregnant women visiting the outpatient clinic. Study information was also handed out to women during regular visits to the outpatient clinic. Moreover, women scheduled for caesarean section, were provided with study information on a second occasion during hospitalization prior to surgery, and women admitted to the maternity ward overnight were visited by a research nurse in the morning and asked to participate in the study. For the present analysis we selected women from the TeMPOH-2 cohort for whom a completed bleeding assessment tool providing us with a valid bleeding score and data on volume of blood loss following childbirth were available. Women below 18 years of age or a gestational age below 24 weeks at the time of birth were excluded. Known coagulation disorders or anticoagulant use were not exclusion criteria. Approval for the study was obtained by the Ethical Committee of the Leiden University Medical Centre (P13.246) and of the committee of the Isala Clinics. The study was registered at ClinicalTrials.gov (NCT02149472). Written informed consent was obtained from all participants. Bleeding assessment tools were completed by all women during pregnancy (always prior to childbirth) because of the possibility of recall bias when completing the bleeding assessment tool after birth.

### 2.2 | Bleeding assessment tool

We adjusted the condensed MCMDM-1VWD bleeding assessment tool to a written questionnaire that could be used as a self-assessment bleeding score. Medical terminology was converted into lay language and detail was added to items that needed extra



**FIGURE 1** Inclusion flowchart

explanation or examples that would otherwise be given by an expert (Data S1). The agreement between patient self-assessment and expert assessment of the bleeding symptoms was evaluated and found to be excellent: eight women participating in the study completed the TeMPOH-2 study self-BAT (without assistance) followed by the condensed MCDM-1VWD (administered by an expert). In both questionnaires, the same scoring key is applied. Scores were equal in seven of the eight participants, and a difference of +1 was found in one woman.

### 2.3 | Calculation of bleeding score

The questionnaire (derived from the condensed MCDM-1VWD BAT) comprised 12 areas of bleeding: epistaxis, cutaneous, bleeding from minor wounds, oral cavity, gastrointestinal bleeding, tooth extraction, surgery, menorrhagia, postpartum hemorrhage, muscle hematoma, hemarthrosis, central nervous system bleeding. The condensed MCDM-1VWD BAT as assessed in a primary care setting yielded a mean bleeding score in 100 healthy individuals of 0.16 with

a range of normal bleeding scores from  $-3.2$  to  $+3.6$ .<sup>15</sup> Accordingly, we considered a score of  $\geq 4$  as abnormal.

### 2.4 | Data collection

Participants completed the bleeding assessment tool either via a paper-based or web-based questionnaire. Results of the paper-based questionnaire were scanned and evaluated by TeleForm. TeleForm is a software application that enables the creation of forms for data collection and reads the returned data by use of a scanner. After processing and verifying of the data by a trained operator, data were exported from TeleForm into a SPSS database for further analyses. The web-based questionnaire was created in NetQ, an online questionnaire tool. Data were automatically exported to SPSS and then verified. Bleeding scores were calculated for all participants from the data derived from the bleeding assessment tool. Additional information was collected by well-trained research nurses who performed comprehensive chart reviews. Data were recorded from medical files available at the maternity ward for the following parameters: maternal age at the time of birth, parity, gestational age, mode of birth, presence of preeclampsia or Hemolysis Elevated Liver Enzymes Low Platelet (HELLP) syndrome, presence of a coagulation disorder, anti-coagulant use, and total volume of blood loss. Blood loss was measured by weighing gauzes and all other soaked materials and by the use of a collector bag and suction system in the operating theatre. In case women had experienced postpartum hemorrhage additional information was collected on cause of bleeding and treatment.

### 2.5 | Statistical analyses

Bleeding scores were calculated using the tool specific scoring key. Sensitivity, specificity, positive and negative predictive value and the area under the receiver operator curve (AUC's) were calculated to quantify test characteristics of the bleeding score in relation to the occurrence of postpartum hemorrhage defined as more than 1000-mL blood loss (primary endpoint) as well as more than 2000-mL blood loss. Positive and negative predictive value were also calculated for all separate items of the bleeding score (epistaxis, cutaneous, bleeding from minor wounds, oral cavity, gastrointestinal bleeding, tooth extraction, surgery, menorrhagia, postpartum hemorrhage, muscle hematoma, hemarthrosis, central nervous system bleeding). To evaluate the possibility of selection bias due to a high number of women with caesarean sections, sensitivity analyses were performed excluding women who gave birth by elective caesarean section.

## 3 | RESULTS

### 3.1 | Patient characteristics

Over the 3-year TeMPOH-2 inclusion period, 1147 women for whom data were available on total volume of blood loss following childbirth, completed the bleeding assessment tool (Figure 1). Baseline characteristics are reported in Table 1. Women were on average

32 years of age (IQR 29-35), gave birth at a median gestational age of 39.0 weeks (IQR 38.1-40.3) and 30% delivered by caesarean section. In our cohort (197/1147) 17.2% of women experienced postpartum hemorrhage  $\geq 1000$  mL and (55/1147) 4.8% of women lost more than 2000 mL of blood following birth. Primary cause of postpartum hemorrhage was uterine atony or retained placenta in 68% of women and 25% of bleeds were the result of a surgical cause. Bleeding scores ranged from -3 to 13, with a median of 1 (IQR -1 to 3). Of the women in our cohort, (147/1147) 12.8% had an abnormal bleeding score of  $\geq 4$ . The distribution of bleeding scores plotted to categories of increasing volume of blood loss is shown in Figure 2. The bubble plot displays number of women per bleeding score categorized in increasing volumes of blood loss. Larger bubbles represent a higher patient count.

### 3.2 | Discriminative ability of the bleeding score

The ability of the score to discriminate women with postpartum hemorrhage  $\geq 1000$  mL from women without postpartum hemorrhage was poor, area under receiver operating curve 0.53 (95% CI 0.49-0.58). For postpartum hemorrhage exceeding 2000 mL of blood loss the area under receiver operating curve was 0.60 (95% CI 0.52-0.68), showing an increase but still a rather poor discriminative power. Among 147 women with an abnormal bleeding score ( $\geq 4$ ) the incidence of postpartum hemorrhage of  $\geq 1000$  mL was 18.4% ( $n = 27$ ), and the incidence of postpartum hemorrhage exceeding 2000 mL was 8.8% ( $n = 13$ ). Of the 1000 women with a normal bleeding score, 170 (17%) developed postpartum hemorrhage

$\geq 1000$  mL and 42 (4.2%) developed blood loss exceeding 2000 mL (Table 2). Results of the sensitivity analyses excluding women with an elective caesarean section were similar to those of the main analyses (Table S1).

### 3.3 | Bleeding symptoms

A history of postpartum hemorrhage was associated with postpartum hemorrhages of  $\geq 1000$  mL and  $\geq 2000$  mL. Epistaxis, postsurgery blood loss and a history of postpartum hemorrhage were associated with the development of blood loss exceeding 2000 mL (Table 3). A total of 122 women had a positive score on epistaxis or postsurgery blood loss; 13 (10.7%) of them developed blood loss exceeding 2000 mL.

## 4 | DISCUSSION

This prospective two-center cohort study describes the usefulness of a bleeding assessment tool to predict postpartum hemorrhage. In our cohort of 1147 women, the ability of the bleeding score to contribute to the discrimination between women with and without postpartum hemorrhage was poor.

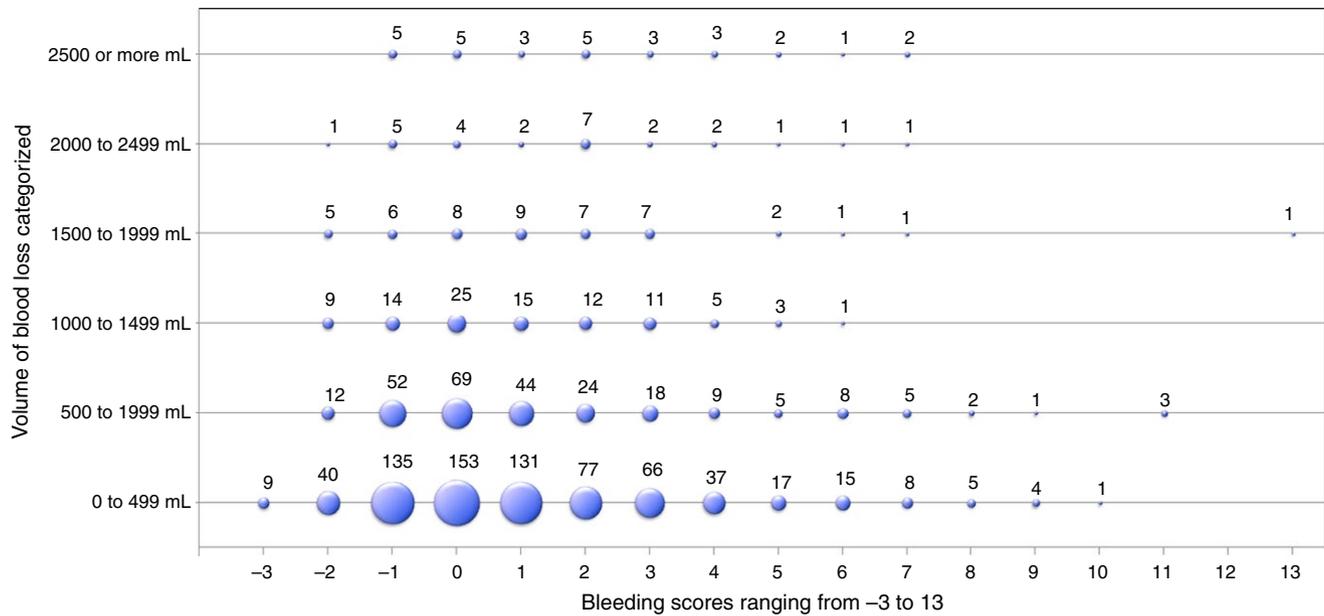
Our results suggest that a questionnaire does not contribute to the identification of women who will develop postpartum hemorrhage. Since the main causes for postpartum hemorrhage are obstetrical it might be not surprising that a tool initially developed for the diagnosis of bleeding disorders does not associate with postpartum

**TABLE 1** Characteristics of participants\*

|                                      | Total               | LUMC                | Isala               | Postpartum hemorrhage $\geq 1000$ mL |                     |
|--------------------------------------|---------------------|---------------------|---------------------|--------------------------------------|---------------------|
|                                      |                     |                     |                     | No                                   | Yes                 |
| Patients                             | 1147                | 818                 | 329                 | 950                                  | 197                 |
| Age in years                         | 32 (29 to 35)       | 32 (30 to 35)       | 31 (28 to 35)       | 32 (29 to 35)                        | 32 (29 to 36)       |
| Nulliparity                          | 39%                 | 41%                 | 33%                 | 38%                                  | 43%                 |
| Gestational age in weeks             | 39.0 (38.1 to 40.3) | 38.9 (37.9 to 40.1) | 39.1 (38.1 to 40.6) | 39.0 (38.1 to 40.3)                  | 39.1 (38.0 to 40.6) |
| Bleeding score                       | 1 (-1 to 2)         | 1 (-1 to 2)         | 1 (0 to 2)          | 1 (-1 to 2)                          | 1 (0 to 3)          |
| Mode of birth                        |                     |                     |                     |                                      |                     |
| Caesarean section                    | 30%                 | 33%                 | 23%                 | 30%                                  | 27%                 |
| Vaginal                              | 70%                 | 67%                 | 77%                 | 70%                                  | 73%                 |
| Comorbidity                          |                     |                     |                     |                                      |                     |
| Preeclampsia/HELLP                   | 5%                  | 5%                  | 4%                  | 4%                                   | 9%                  |
| Anticoagulant use                    | 8%                  | 10%                 | 3%                  | 8%                                   | 7%                  |
| Known coagulation disorder (VWD)     | 1%                  | 5%                  | 2%                  | 1%                                   | 0%                  |
| Total volume of blood loss in liters | 0.4 (0.3 to 0.7)    | 0.4 (0.2 to 0.7)    | 0.4 (0.3 to 0.6)    | 0.3 (0.2 to 0.5)                     | 1.5 (1.2 to 2.0)    |
| PPH $\geq 1000$ mL                   | 17%                 | 17%                 | 16%                 | NA                                   | NA                  |
| PPH $\geq 2000$ mL                   | 5%                  | 4%                  | 4%                  | NA                                   | NA                  |

PPH, postpartum hemorrhage; VWD, von Willebrand disease.

\*Values are median (25-75 percentile) or percent.



**FIGURE 2** Bubble plot of bleeding score versus volume of blood loss

**TABLE 2** Sensitivity and specificity, positive and negative predictive value of an abnormal bleeding score\* for the occurrence of postpartum hemorrhage  $\geq 1000$  mL and  $\geq 2000$  mL

| Bleeding score and PPH | AUC (95% CI)     | Sensitivity (95% CI) | Specificity (95% CI) | NPV (95% CI)     | PPV (95% CI)     |
|------------------------|------------------|----------------------|----------------------|------------------|------------------|
| $\geq 1000$ mL         | 0.53 (0.49-0.58) | 13.7 (9.39-19.5)     | 87.4 (85.0-89.4)     | 83.0 (80.5-85.2) | 18.4 (12.7-25.8) |
| $\geq 2000$ mL         | 0.60 (0.52-0.68) | 23.6 (13.7-37.3)     | 87.7 (85.6-89.6)     | 95.8 (94.3-96.9) | 8.8 (5.0-14.9)   |

AUC, area under the curve; CI, confidence interval; PPH, postpartum hemorrhage.

\*abnormal bleeding score is defined as score  $\geq 4$ .

hemorrhage. However, adding two questions on history of nosebleeds and postsurgery blood loss to a standard medical history did contribute to the identification of women with a higher risk of larger bleeds. Thus, especially in women with already known risk factors for postpartum hemorrhage, knowledge of an abnormal bleeding score could be of added value while composing a personalized birth plan.

#### 4.1 | Strength and limitations of this study

A strength of our study is that we included a large cohort of 1147 pregnant women who had completed a bleeding assessment tool prior to childbirth with complete follow-up until childbirth. To rule out the possibility of recall bias, the questionnaires were only completed by women before giving birth. Moreover, we used a self-BAT derived from the validated condensed MCMDM-1VWD-BAT which was proven to be a reliable tool.

We can't rule out the presence of bias in our study. A first possible source of bias is selection bias. In our cohort, the incidence of postpartum hemorrhage was higher than expected (17.2% vs expected 6%-8%). This could be a result of the fact that the TeMPOH-2 study

included women in a university hospital (LUMC) and a non-university hospital with a neonatal intensive care unit department on site, resulting in a population with a higher a priori risk of postpartum hemorrhage. Another possible explanation for the higher incidence of postpartum hemorrhage is the known underestimation of volume of blood loss in case of visual estimation. Volume of blood loss in the TeMPOH-2 study was objectively measured, which could have led to a more realistic, yet higher, incidence of postpartum hemorrhage. Yet, if anything, a higher incidence might have influenced the predictive value of the questionnaire in a positive way.<sup>22,23</sup> We therefore infer that the poor predictive value of our questionnaire is not the result of selection bias.

A second possible source of bias is misclassification of the endpoint postpartum hemorrhage. Volume of blood loss was supposed to be weighed in accordance with the study protocol, but we cannot rule out that sporadically weighing was complemented by visual estimation. When visual estimation is used, it is well-known that volume of blood loss is in most cases underestimated.<sup>24</sup> This may have led to potential misclassification of women in our cohort, which in this case may have caused an underestimation of incidence of postpartum hemorrhage.

**TABLE 3** Sensitivity and specificity, positive and negative predictive value of bleeding symptoms for the occurrence of postpartum hemorrhage  $\geq 1000$  mL and  $\geq 2000$  mL\*

|                               | Sensitivity (%) | Specificity (%) | NPV (%)         | PPV (%) |
|-------------------------------|-----------------|-----------------|-----------------|---------|
| <b>Epistaxis</b>              |                 |                 |                 |         |
| PPH 1000                      | 4.6             | 95.5            | 82.8            | 17.3    |
| PPH 2000                      | 10.9            | 95.8            | 95.5            | 11.5    |
| <b>Cutaneous</b>              |                 |                 |                 |         |
| PPH 1000                      | 15.2            | 87.5            | 83.3            | 20.1    |
| PPH 2000                      | 18.2            | 87.3            | 95.5            | 6.7     |
| <b>Minor wounds</b>           |                 |                 |                 |         |
| PPH 1000                      | 3.6             | 95.8            | 82.7            | 14.9    |
| PPH 2000                      | 3.6             | 95.9            | 95.2            | 4.3     |
| <b>Oral Cavity</b>            |                 |                 |                 |         |
| PPH 1000                      | 66.0            | 31.2            | 81.5            | 16.6    |
| PPH 2000                      | 63.6            | 31.4            | 95.5            | 4.5     |
| <b>Gastrointestinal</b>       |                 |                 |                 |         |
| PPH 1000                      | 2.5             | 97.4            | 82.8            | 16.7    |
| PPH 2000                      | 1.8             | 97.3            | 95.2            | 3.3     |
| <b>Tooth extraction</b>       |                 |                 |                 |         |
| PPH 1000                      | 2.5             | 95.7            | 82.6            | 10.9    |
| PPH 2000                      | 3.6             | 96.0            | 95.2            | 4.3     |
| <b>Surgery</b>                |                 |                 |                 |         |
| PPH 1000                      | 8.1             | 93.5            | 83.1            | 20.5    |
| PPH 2000                      | 12.7            | 93.5            | 95.5            | 9.0     |
| <b>Menorrhagia</b>            |                 |                 |                 |         |
| PPH 1000                      | 16.2            | 82.8            | 82.7            | 16.4    |
| PPH 2000                      | 14.5            | 82.9            | 95.1            | 4.1     |
| <b>PPH</b>                    |                 |                 |                 |         |
| PPH 1000                      | 30.5            | 84.2            | 85.4            | 28.6    |
| PPH 2000                      | 40.0            | 82.8            | 96.5            | 10.5    |
| <b>Muscle hematoma</b>        |                 |                 |                 |         |
| PPH 1000                      | 4.1             | 96.4            | 82.9            | 19.0    |
| PPH 2000                      | 1.8             | 96.2            | 95.1            | 2.4     |
| <b>Hemarthrosis</b>           |                 |                 |                 |         |
| PPH 1000                      | 1.5             | 99.3            | 82.9            | 30.0    |
| PPH 2000                      | 0.0             | 99.1            | NA <sup>†</sup> | NA      |
| <b>Central nervous system</b> |                 |                 |                 |         |
| PPH 1000                      | 0.0             | 99.8            | NA              | NA      |
| PPH 2000                      | 0.0             | 99.8            | NA              | NA      |
| <b>Epistaxis and surgery</b>  |                 |                 |                 |         |
| PPH 1000                      | 12.2            | 89.7            | 83.1            | 19.7    |
| PPH 2000                      | 10.7            | 90.0            | 95.9            | 10.7    |

PPH, postpartum hemorrhage.

\*Incidence of PPH 1000 mL in the cohort was 17.2%. Incidence of PPH 2000 L in the cohort was 4.2%.

<sup>†</sup>Not calculated because of small numbers.

Notwithstanding the high incidence of postpartum hemorrhage, the discriminative power of our bleeding score to detect women with increased risk of postpartum hemorrhage was poor. This could mean, that the predictive ability of the bleeding score in a more general population of pregnant women is even worse.

## 4.2 | Comparison with other studies

To the best of our knowledge, this study is the first to examine the value of bleeding scores evaluated during pregnancy as a screening tool for the identification of women with an increased risk of excessive blood loss postpartum. Our findings corroborate results of previous studies in different patient populations. In a cohort of 7730 pediatric patients undergoing adenotonsillectomy, the efficacy of a preoperative bleeding questionnaire and coagulation screening in predicting hemorrhage associated with the procedure was studied.<sup>18</sup> When both an abnormal bleeding score and positive coagulation screening were combined, a statistically slightly higher likelihood of postoperative bleeding was found. However, an abnormal bleeding score without the additional coagulation screen did not have any predictive value for the occurrence of postsurgery hemorrhage. In a study in von Willebrand disease families (affected and unaffected family members), the association between spontaneous mucocutaneous bleeding symptoms and bleeding after tooth extraction or surgery was evaluated.<sup>20</sup> The mucocutaneous bleeding score showed a predictive value similar to von Willebrand factor level for bleeding after tooth extraction (AUC 0.71) and an even better value for prediction of bleeding after surgery (AUC 0.78). In the area of von Willebrand disease, bleeding scores are used for their high negative predictive value, indicating that a normal bleeding score can help exclude a clinically significant bleeding disorder.<sup>25</sup> In line with this, in a study of 217 individuals being prospectively investigated for von Willebrand disease, seventeen individuals with negative bleeding scores underwent major surgery, and none experienced significant bleeding. No previous studies were found that examined the predictive value of the use of bleeding scores in the field of childbirth. In contrast with von Willebrand disease, postpartum hemorrhage is a condition that is known for its multifactorial origin. We have assessed that a high bleeding score can to a certain extent contribute to an individual patients risk assessment prior to birth. However, the question whether postpartum hemorrhage will actually occur, can only be answered during the course of active bleeding, depending on the obstetric challenges in tone, tissue, trauma and thrombin that will develop along the way.<sup>19</sup>

## 4.3 | Clinical implications

No evidence was found to support adding a bleeding assessment tool to the review of a pregnant woman's medical history for the prediction of postpartum hemorrhages of  $\geq 1000$  mL. However, adding two questions on history of nosebleeds and postsurgery blood

loss to a standard medical history could enable a clinician to identify women with a higher risk of postpartum hemorrhage exceeding 2000 mL. Clinicians should contemplate whether they find this of clinical significance for individual patients.

## 5 | CONCLUSION

When used as a screening tool contributing to the identification of pregnant women with an increased risk of postpartum hemorrhage prior to childbirth, a bleeding questionnaire lacks discriminative power. We found no evidence to support the added value of a bleeding assessment tool for the prediction of postpartum hemorrhage.

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## RELATIONSHIP DISCLOSURE

The authors declare that there are no conflict of interests regarding the publication of this article.

## AUTHOR CONTRIBUTIONS

A. Gillissen and J. van der Bom designed the research and A. Gillissen wrote the original draft of the paper. A. Gillissen and C. Caram-Deelder were responsible for data curation, analyses of results and created the figures and tables. J. Eikenboom was involved in conceptualization and methodology and reviewed and edited the paper. J. van der Bom, T. van den Akker, D. Henriquez, K. Bloemenkamp, and S. Nij Bijvank reviewed and edited the paper. J. van der Bom and T. van den Akker supervised the project. All authors have read and approved the manuscript for submission.

## ORCID

Ada Gillissen  <https://orcid.org/0000-0001-9586-276X>

Thomas van den Akker  <https://orcid.org/0000-0002-9890-9145>

Camila Caram-Deelder  <https://orcid.org/0000-0003-3161-5684>

Dacia D. C. A. Henriquez  <https://orcid.org/0000-0003-3164-8611>

Sebastiaan W. A. Nij Bijvank  <https://orcid.org/0000-0003-4723-8238>

Kitty W. M. Bloemenkamp  <https://orcid.org/0000-0002-1377-4625>

Jeroen Eikenboom  <https://orcid.org/0000-0002-3268-5759>

Johanna G. van der Bom  <https://orcid.org/0000-0001-9095-2475>

## REFERENCES

- Say L, Chou D, Gemmill A, Tuncalp O, Moller AB, Daniels J, et al. Global causes of maternal death: a WHO systematic analysis. *Lancet Glob Health*. 2014;2:e323–33.
- van Stralen G, von Schmidt Auf Altenstadt JF, Bloemenkamp KW, van Roosmalen J, Hukkelhoven CW. Increasing incidence of postpartum hemorrhage: the Dutch piece of the puzzle. *Acta Obstet Gynecol Scand*. 2016;95:1104–10.
- Ford JB, Patterson JA, Seeho SK, Roberts CL. Trends and outcomes of postpartum hemorrhage, 2003–2011. *BMC Pregnancy Childbirth*. 2015;15:334.
- Knight M, Callaghan WM, Berg C, Alexander S, Bouvier-Colle MH, Ford JB, et al. Trends in postpartum hemorrhage in high resource countries: a review and recommendations from the International Postpartum Hemorrhage Collaborative Group. *BMC Pregnancy Childbirth*. 2009;9:55.
- Cortet M, Maucourt-Boulch D, Deneux-Tharoux C, Dupont C, Rudigoz RC, Roy P, et al. Severity of post-partum hemorrhage after vaginal delivery is not predictable from clinical variables available at the time post-partum hemorrhage is diagnosed. *J Obstet Gynaecol Res*. 2015;41:199–206.
- Biguzzi E, Franchi F, Ambrogi F, Ibrahim B, Bucciarelli P, Acaia B, et al. Risk factors for postpartum hemorrhage in a cohort of 6011 Italian women. *Thromb Res*. 2012;129:e1–7.
- Al-Zirqi I, Vangen S, Forsen L, Stray-Pedersen B. Prevalence and risk factors of severe obstetric hemorrhage. *BJOG*. 2008;115:1265–72.
- Koopmans CM, van der Tuuk K, Groen H, Doornbos JP, de Graaf IM, van der Salm PC, et al. Prediction of postpartum hemorrhage in women with gestational hypertension or mild preeclampsia at term. *Acta Obstet Gynecol Scand*. 2014;93:399–407.
- Wikkelsso AJ, Hjortoe S, Gerds TA, Moller AM, Langhoff-Roos J. Prediction of postpartum blood transfusion—risk factors and recurrence. *J Matern Fetal Neonatal Med*. 2014;27:1661–7.
- Watson HG, Greaves M. Can we predict bleeding? *Semin Thromb Hemost*. 2008;34:97–103.
- Chee YL, Crawford JC, Watson HG, Greaves M. Guidelines on the assessment of bleeding risk prior to surgery or invasive procedures British Committee for Standards in Haematology. *Br J Haematol*. 2008;140:496–504.
- Chee YL, Greaves M. Role of coagulation testing in predicting bleeding risk. *Hematol J*. 2003;4:373–8.
- Kitchens CS. To bleed or not to bleed? Is that the question for the PTT? *J Thromb Haemost*. 2005;3:2607–11.
- Rodeghiero F, Castaman G, Tosetto A, Battle J, Baudo F, Cappelletti A, et al. The discriminant power of bleeding history for the diagnosis of type 1 von Willebrand disease: an international, multicenter study. *J Thromb Haemost*. 2005;3:2619–26.
- Bowman M, Mundell G, Grabell J, Hopman WM, Rapson D, Lillicrap D, et al. Generation and validation of the Condensed MCMDM-1VWD Bleeding Questionnaire for von Willebrand disease. *J Thromb Haemost*. 2008;6:2062–6.
- Rodeghiero F, Tosetto A, Abshire T, Arnold DM, Coller B, James P, et al. ISTH/SSC bleeding assessment tool: a standardized questionnaire and a proposal for a new bleeding score for inherited bleeding disorders. *J Thromb Haemost*. 2010;8:2063–5.
- Federici AB, Bucciarelli P, Castaman G, Mazzucconi MG, Morfini M, Rocino A, et al. The bleeding score predicts clinical outcomes and replacement therapy in adults with von Willebrand disease. *Blood*. 2014;123:4037–44.
- Licameli GR, Jones DT, Santosuosso J, Lapp C, Brugnara C, Kenna MA. Use of a preoperative bleeding questionnaire in pediatric patients who undergo adenotonsillectomy. *Otolaryngol Head Neck Surg*. 2008;139:546–50.

19. Tosetto A, Rodeghiero F, Castaman G, Goodeve A, Federici AB, Batlle J, et al. A quantitative analysis of bleeding symptoms in type 1 von Willebrand disease: results from a multicenter European study (MCMDM-1 VWD). *J Thromb Haemost*. 2006;4:766–73.
20. Deforest M, Grabell J, Albert S, Young J, Tuttle A, Hopman WM, et al. Generation and optimization of the self-administered bleeding assessment tool and its validation as a screening test for von Willebrand disease. *Hemophilia*. 2015;21:e384–8.
21. Rydz N, James PD. The evolution and value of bleeding assessment tools. *J Thromb Haemost*. 2012;10:2223–9.
22. O'Brien SH. Bleeding scores: are they really useful? *Hematology Am Soc Hematol Educ Program*. 2012;2012:152–6.
23. Toledo P, McCarthy RJ, Hewlett BJ, Fitzgerald PC, Wong CA. The accuracy of blood loss estimation after simulated vaginal delivery. *Anesth Analg*. 2007;105:1736–40.
24. Solomon C, Collis RE, Collins PW. Haemostatic monitoring during postpartum hemorrhage and implications for management. *Br J Anaesth*. 2012;109:851–63.
25. Bowman ML, James PD. Bleeding scores for the diagnosis of von Willebrand Disease. *Semin Thromb Hemost*. 2017;43:530–9.

#### SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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